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MORTALITY OF THE WESTERN PINE BEETLE AND CALIFORNIA FIVE-SPINED IPS IN A FIELD TRIAL OF LINDANE

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A 1.5 percent lindane-diesel oil spray was used near Hat Creek, California, on an outbreak of the western pine beetle (Dendroctonus brevicomis Lec.) and the California five-spined ips (Ips confusus (Lec.)) in ponderosa pine. The infested trees were treated by personnel of the California Division of Forestry and McCloud River Lumber Company during the last three weeks of March 1960, according to procedures outlined in Miscellaneous Paper No. 33. 1/

The survival of beetles emerging from sprayed and unsprayed material was studied to get some estimate of beetle mortality caused by the spray, and therefore, the effectiveness of lindane. Observations on the western pine beetle showed a mortality of 92 percent due to the spray, which is high enough for satisfactory control. 2/ Observations on the ips bark beetle showed a mortality of 100 percent. If the small sample studied can be relied upon as representative, the 1.5 percent lindane spray itself can be said to have produced an adequate level of mortality and was successful in the control program at Hat Creek.

1/ Lyon, Robert L. Directions for using lindane sprays to control ips beetles in California. Pacific Southwest Forest and Range Expt. Sta., Misc. Paper 33, 8 pp., revised May 1960.

2/ "Control" is used here to mean the reduction of beetle damage to or below economically tolerable levels.

MORTALITY OF THE WESTERN PINE BEETLE

METHODS

Samples of infested pine were collected in the field on March 17 and brought to Berkeley on March 25. At this point, most of the insects were mature larvae or pupae. Part of the samples, having a total bark surface of 14.3 square feet, had been sprayed in the course of the control program on the same date they were collected. The remainder, having a total bark area of 6.3 square feet, were unsprayed. In Berkeley, the sprayed samples were caged separately from the unsprayed samples.

The cages used to rear the beetles were made of wood. Each cage had a glass collection jar attached to the front of the cage toward the top. Emerging beetles, being attracted to light, entered these jars from which they were handily collected.

Emergence began feebly on about April 4. The emerging adults were collected daily thereafter and held in covered Petri dishes in a darkened cabinet in the laboratory where the temperature fluctuated narrowly around 70 degrees F. Beetles emerging from the sprayed samples were kept separately from those emerging from the unsprayed samples. The average age of beetles, from the time they entered the collection jars to the time that mortality counts were made, was about 72 hours. Some beetles may have emerged a few hours before showing up in the collection jars, but since the untreated samples were handled the same way as the treated samples, there should be no important effect on results.

In the mortality counts, both the dead and moribund beetles were tallied. Beetles were considered dead when no movement was elicited by probing. Beetles were considered moribund when movement of appendages was feeble and coordinated movement was wanting, or when the elytra were locked open and appendages moved only feebly, a symptom of advanced and irreversible lindane poisoning in this insect.

RESULTS

Total emergence (table 1) was 180 beetles from the untreated, and 1,230 beetles from the treated samples (29 and 86 beetles per square foot of bark surface, respectively). The pattern of emergence is shown in figure 1. Emergence on April 13 was not plotted because the cages were cleaned at this time to remove those beetles that were killed so quickly they could not make their way to the glass collection jars. Emergence from the unsprayed samples was especially low. Both the western pine beetle and ips beetle had attacked these samples, and emergence of both species may have been reduced because of the competition for available space. No ips beetles emerged from the treated samples. Thirty-six (of which 28 beetles or 78 percent died in 72 hours) emerged from the untreated ones. This is too small a sample to be meaningful and is not considered further.

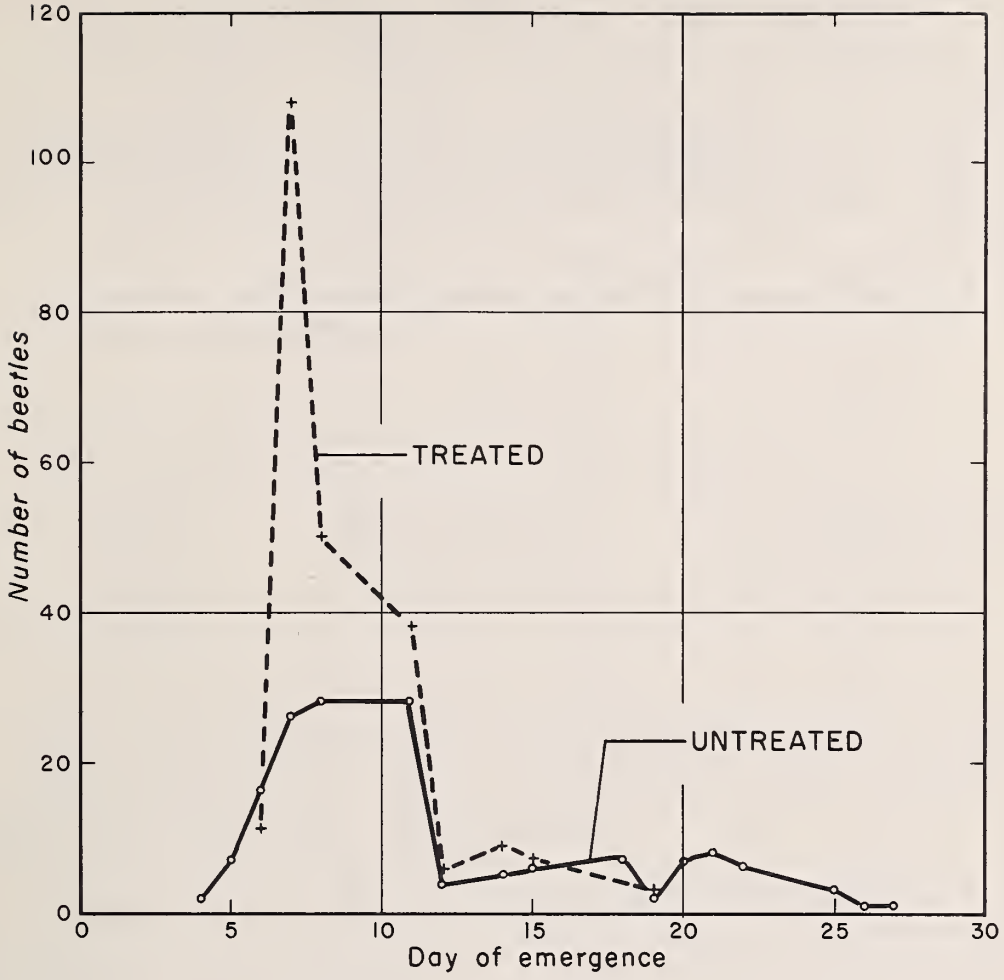

Figure 1.--Emergence of western pine beetle from samples of ponderosa pine.

Mortality of the western pine beetle from the untreated samples was 9 percent and from the treated samples 93 percent. When corrected for natural mortality, the control due to the spray alone was 92 percent.

Table 1.--Mortality of western pine beetle in ponderosa pine treated with a 1.5 percent lindane-diesel oil spray--Hat Creek, 1960

Date of emergence	Untreated		Treated	
	No. beetles	No. dead and moribund at 72 hrs.	No. beetles	No. dead and moribund at 72 hrs.
3-28-60	1	0	1	1
4-4-60	2	0	--	--
5	7	1	--	--
6	16	1	11	7
7	26	2	108	73
8	28	3	70	43
11	28	3	38	38
12	4	0	6	5
13	22	3	1/ 977	967
14	5	1	9	7
15	6	1	7	2
18	7	0	--	--
19	2	0	3	3
20	7	0	--	--
21	8	0	--	--
22	6	0	--	--
25	3	0	--	--
26	1	0	--	--
4-27-60	1	1	--	--
Total	180	16	1,230	1,146
Percent	--	9	--	93

1/ Cages opened and cleaned of emerged beetles.

MORTALITY OF THE CALIFORNIA FIVE-SPINED IPS

The field trial of 1.5 percent lindane was intended as a test for the control of the western pine beetle. But much of the pine was infested with the California five-spined ips, and this was treated along with pine infested with the western pine beetle, using the same 1.5 percent lindane solution. A 0.2 percent lindane solution is normally recommended for controlling the ips bark beetle, so the effectiveness of the 1.5 percent spray was not under test on this insect. However, a 1.5 percent spray should be more than adequate for ips control and it was felt worthwhile to determine if this were true while it was convenient to do so.

METHODS

The effect of the spray on ips was judged by a different method than the one used for the western pine beetle. Treated and untreated

infested pine bolts were caged separately at the Forest Service's Hat Creek Forest Insect Field Laboratory in wire screen cages, along with freshly cut, uninfested material. The purpose was to gauge the effectiveness of the spray by comparing the relative ability of the insects in sprayed and unsprayed material to emerge and successfully attack the green material. This would serve as an expression of spray effectiveness.

Each lot of green pine bolts in the cages had 2.1 square feet of bark surface. The treated pine bolts had 4.8 square feet, and the untreated ones had 4.5 square feet.

RESULTS

Findings are shown in the following tabulation:

	No. dead beetles	No. of attacks on green pine	No. of beetles emerged from green pine
Treated	669	0	0
Untreated	100	46	217

The number of dead beetles shown in the first column represents beetles that died in their galleries under the bark before they could emerge and attack green pine, and those beetles that died after emergence and did not successfully attack the green pine.

Of the 217 beetles that emerged from unsprayed samples, 27 beetles or 12 percent died when held for 72 hours. Emergence was almost, but not quite, complete when observations were terminated, so the total emergence may have been slightly higher.

The results show, as expected, that the 1.5 percent lindane spray was 100 percent effective in killing ips adults in the pine samples studied and in preventing their attack on green uninfested pine bolts caged with them.

DISCUSSION

A 92 percent kill should be high enough to control the western pine beetle, but, it is precarious to extrapolate from our limited laboratory observations and conclude from them alone that control was actually attained. Control does not automatically follow from the application of an adequate insecticide; the spray can be adequate for the job, but the control effort can fail when beetles are missed for reasons such as high spotting error, poor spray application, poor timing, and invasion of beetles from adjacent unsprayed areas. So, even if a spray is effective, it is still important to know that enough beetles were actually treated with the spray. Otherwise the success of a control program cannot be judged accurately.

An hypothetical example may help to show the important influence that insects missed by the spray will have on the outcome of a control effort. If we assume an epidemic is rising at the rate of 50 percent each generation and timber losses are already 400 percent of normal, and if we assume that 0.1 percent of the stand is normal loss (and economically tolerable), then epidemic losses would be 0.4 percent of the stand. With loss rising at the rate of 50 percent each generation, one more generation will see losses 600 percent above normal. This example would represent a severe epidemic and would probably not under estimate conditions that prevailed in the Hat Creek area before the 1959 control project was undertaken.

Under the above conditions, if 100 percent of the beetles were contacted or treated by the spray, control would be theoretically possible if the spray reduced adult survival by 83 percent. A reduction in adult survival of 83 percent would bring losses back down to 0.1 percent of the stand which is economically tolerable and which therefore constitutes control as the term is used in this paper.

However, if only 90 percent of the beetles were treated by the spray, then a 93 percent kill would be needed to get control (reduce losses to the economically tolerable level of 0.1 percent of the stand). If only 80 percent of the beetles were treated, control could no longer be attained even with 100 percent kill by the spray.

Two points relevant to an evaluation of the outcome of the Hat Creek spray program became apparent from laboratory observations, and may serve as examples to illustrate the above discussion. The first point, which mitigates against control, was that parent adults had already emerged by the time spraying was begun. These insects were missed by the spray, therefore, and they may comprise a substantial part of the total emergence. The second point, that favors control, was that spray operations were completed before the new adults began to emerge.

All treated samples brought to the laboratory for rearing were checked for the presence of a lindane deposit on the bark surface; no deposit whatever could be detected by the usual method of examining samples of bark under the dissecting scope. Barring contrary developments in the field, the lindane deposit as indicated by the sample logs was completely within the bark tissue. This means that mortality was brought about largely through stomach action, and that contact action resulting from a brief exposure to the bark surface may be lacking or negligible. Evidence for a predominately stomach-type action is seen from the very high proportion of beetles so debilitated at emergence that they could not reach the collection jar (table 1, collection of 4-13-60). Lindane is slow-acting and would not have prevented entrance to the collection jar if contact with the insecticide were made only at the bark surface. But such seemingly rapid toxic action can best be explained by an intake of lindane with the bark tissue by

the adults while boring out. Virtually all beetles dead in the cages, not able to reach the collection jar, had their elytra locked open, which is the most conspicuous symptom of lindane poisoning.

The high mortality obtained in the absence of a detectable surface deposit of lindane poses the question of the relative importance of contact and stomach action. It will be important to determine if control is most effectively achieved through contact or stomach action, or a combination of the two.